Indicator: Fertilizer Applied For Agricultural Purposes – (063)

Commercial fertilizers are applied to agricultural crops to increase crop yields. Prior to the 1950s, most farming occurred on small family farms with limited use of chemicals. The shift since then to larger corporate farms has coincided with the use of chemical fertilizers in modern agricultural practices. The three major types of commercial fertilizer used in the United States include nitrogen, phosphate, and potash. Nitrogen (N) is primarily found in soil as nitrate, and is both extremely soluble and mobile: it can lead to nuisance algal growths, mostly in downstream estuaries, and can cause contamination of drinking water. Phosphorous (P) is primarily found as phosphate, and while less soluble, is still easily transportable with soil in runoff; it can lead to nuisance algae and plant growth, often in freshwater streams, lakes, and estuaries. Potash is the oxide form of potassium (K) and its principal forms as fertilizer are potassium chloride, potassium sulfate, and potassium nitrate. When used at recommended application rates, there are little to no adverse effects from potassium, but it is a common component of mixed fertilizers used for high crop yields and is tracked in the fertilizer use surveys conducted..

This indicator shows total commercial fertilizer use of the three major fertilizers in tons per year (expressed as N, P, or K) from 1960 to 2003, based on an annual survey for agricultural crops conducted by the United States Department of Agriculture (USDA) National Agricultural Statistics Service (NASS). NASS produces an annual *Agricultural Chemical Usage* report of 4-5 targeted field crops that is based on data compiled from the Agricultural Resources Management Survey (ARMS), which surveys farmers in major agriculture producing states that together account for 80-99 percent of total U.S. acreage planted. The indicator also shows total use of commercial fertilizer for key crops – corn, soybeans, and cotton – by EPA region for the year 2000.

What the Data Show

Based on fertilizer sales data, NASS estimates show that total use of the three major commercial fertilizers has steadily increased, from 7.5 million nutrient tons per year (MT/yr) in 1960 to 21.3 MT/yr in 2003 (Fig 063-1). Following a large decrease in 1983 to 18.1 MT/yr primarily due to federal land conservation programs that removed cropland from production and decreasing acreage harvested by 16%, aggregate use has fluctuated between 19-23 MT/yr over the last twenty. Nitrogen accounted for the steepest increase in use, from 2.7 MT/yr in 1960 to 12.0 MT/yr in 2003, and now accounts for over 55% of total fertilizer use, up from nearly 37% in 1960. In that same period, phosphate and potash use grew more slowly and remained steady between 4 and 5 MT/yr each. Both phosphate and potash declined by approximately 1 MT/yr since reaching their peak usage in the late 1970s, and now account for approximately 20% and 24% of total fertilizer usage, as compared to 34% and 29% in 1960.

Estimates from annual NASS *Acreage* reports show that similar amounts of land have been planted with corn each year since 1995. The acreage planted in corn has totaled between 77–80 million acres, an increase from 66 million acres planted in 1970. While grown in most states, corn production is concentrated in the middle of the country (EPA Regions 5 and 7). The acreage of land planted in cotton was 15.5 million acres in 2000 and has averaged between 12-14 million acres since 1990. Major cotton-producing states include 17 southern states located in EPA Regions 4, 6, and 9. Soybean acreage represents the fastest growing crop in total acreage, increasing from 57.8 million acres in 1990 to 74.3 million acres in 2000. The majority of soybean acreage (80%) is concentrated in the upper Midwest in EPA Regions 5 and 7.

Overall, the ARMS states for these three crops used slightly more than 10.8 MT/yr of fertilizer in 2000, or about one half of the 21.6 MT/yr estimated by USDA's Economic Research Service for the entire United States. Of this amount, slightly less than half (5.25 MT/yr) was in applied in EPA Region 5, of which 4.6

MT/yr was used for corn (Fig 063-2). An additional 3.2 MT/yr was applied in EPA Region 7 in corn or soybeans. Most of the remainder was used in EPA regions 4 and 6, primarily on cotton.

Indicator Limitations

- USDA national estimates of fertilizer use are based on sales data provided by states, and not on actual fertilizer usage, and are susceptible to differing reporting procedures or accuracy from state to state.
- Within the ARMS, not all states report fertilizer data every year for each crop type, so it is hard to establish year to year trends (a decrease in fertilizer use for a specific crop might be attributed to failure of a state to report, rather than an actual decrease of use).
- ARMS sampling is limited to program states, which represent only 65-99% of crops, depending on crop types
- The NASS *Acreage* report has estimates for the entire nation by crop, while fertilizer data are based on USDA program states. Even though they represent the majority of U.S. planted acreage, often over 90%, the ability to generalize the data to the country as a whole is unknown, as non-program states, while representing a small percentage of a crop, might have much different application rates due to climate, weather, etc.
- Fertilizer applied to trees that are considered agricultural-type crops (e.g., nut producing trees) are included in field crop summaries; but fertilizer applied in silviculture (e.g., southern pine plantations) are not covered by the NASS data collection system.

Data Sources

National Agricultural Fertilizer Use Estimates

Agricultural Resources and Environmental Indicators Report, USDA, Economic Research Service, 2003. http://www.ers.usda.gov/publications/arei/ah722/

U.S. Fertilizer Use, The Fertilizer Institute, 2004. http://www.tfi.org/Statistics/USfertuse2.asp

Email Correspondence (10/29/04), Wen Huang, USDA Economic Research Service

Fertilizer Estimates for ARMS Crop Program States

Agricultural Chemical Usage, Field Crop Summary 2000, USDA National Agricultural Statistics Service (NASS), May 2001. http://usda.mannlib.cornell.edu/reports/nassr/other/pcu-bb/agcs0501.pdf.

Acreages of Crop Production Estimates

Acreage, USDA, National Agricultural Statistics Service, 2004. http://usda.mannlib.cornell.edu/reports/nassr/field/pcp-bba/

Agricultural Statistics 2004, USDA, National Agricultural Statistics Service, 2004. http://www.usda.gov/nass/pubs/agr04/acro04.htm

USDA Briefing Rooms – Corn, Cotton, and Soybeans and Oil Crops, Economic Research Service http://www.ers.usda.gov/briefing/

Graphics

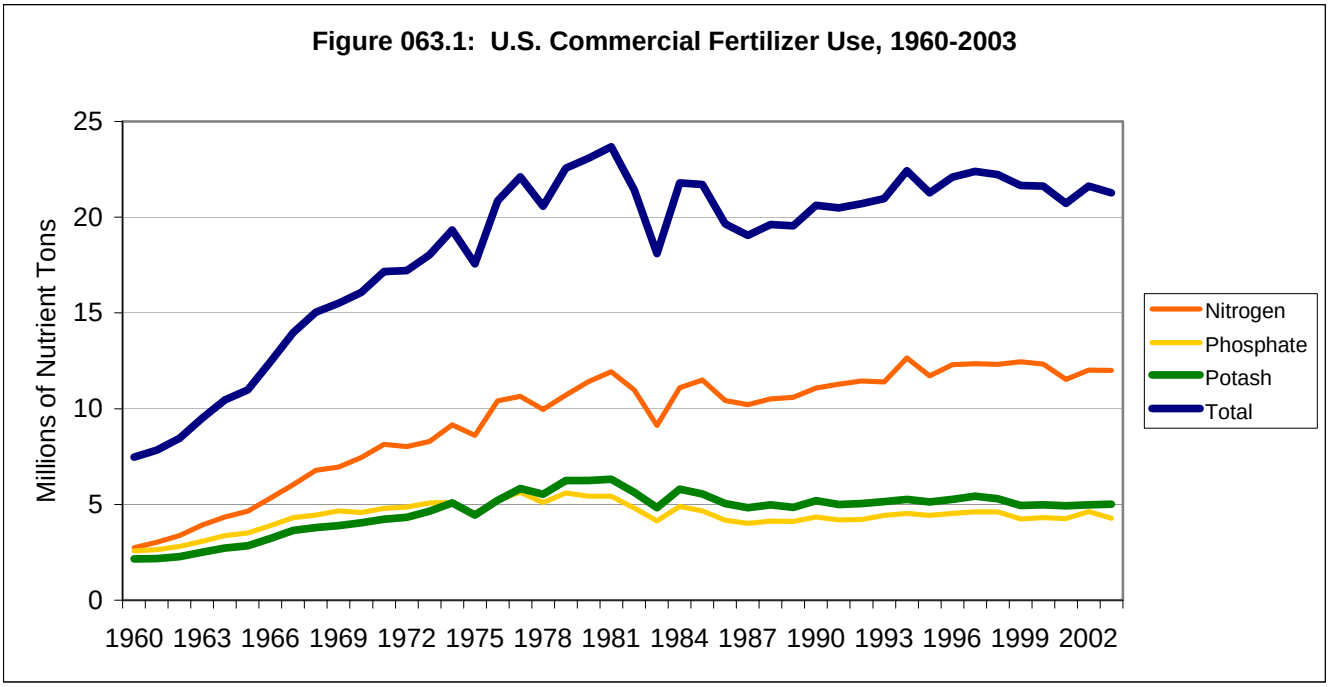
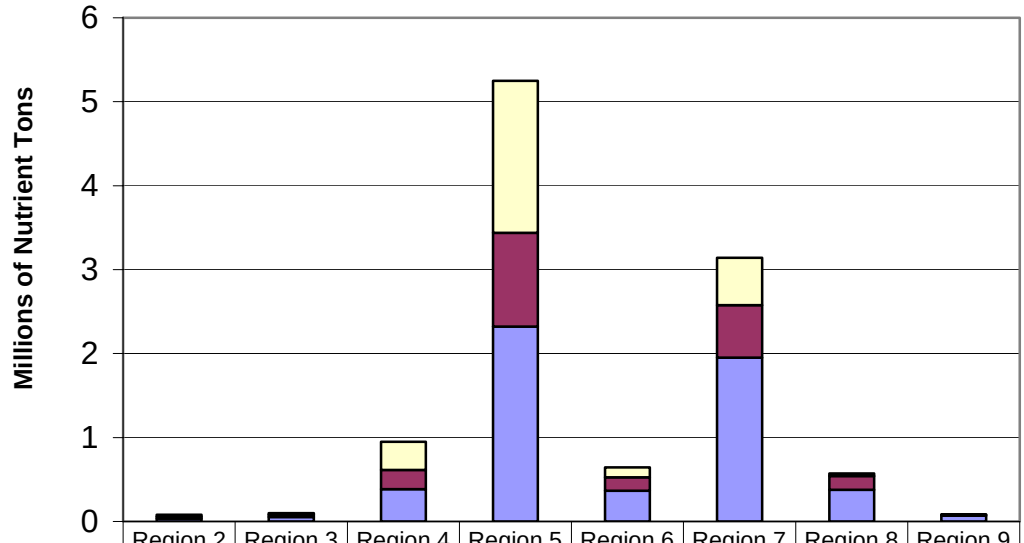


Figure 063.1: U.S. Commercial Fertilizer Use, 1960-2003
Millions of Nutrient Tons
25
20
15
10
5
0
1960 1963 1966 1969 1972 1975 1978 1981 1984 1987 1990 1993 1996 1999 2002
Nitrogen
Phosphate
Potash
Total

Figure 063.2: Fertilizer Use by EPA Region for 3 Major Crops (Corn, Cotton, and Soybeans) in 2000 (ARMS Program States)



	Region 2	Region 3	Region 4	Region 5	Region 6	Region 7	Region 8	Region 9
Potash	0.0209	0.01795	0.3376	1.8086	0.11735	0.56525	0.0322	0.0031
Phosphate	0.0228	0.02995	0.2289	1.1192	0.15925	0.62675	0.16295	0.00865
Nitrogen	0.0356	0.0519	0.384	2.3199	0.3674	1.9507	0.378	0.0705

064 - Figure 2

R.O.E. Indicator QA/QC

Data Set Name: FERTILIZER APPLIED FOR AGRICULTURAL PURPOSES
Indicator Number: 063 (89343)
Data Set Source: NASS
Data Collection Date: Ongoing: 1991-present, Ongoing:1975-present
Data Collection Frequency: 1 Year, 1 Year
Data Set Description: Amount of Fertilizer Applied for Agricultural Purposes by Type of Fertilizer, Crop, and Geographic Region
Primary ROE Question: What are the trends in chemicals used on the land and their effects on human health and the environment?(Chemicals to include toxic substances, pesticides, fertilizers, etc.)

Question/Response

T1Q1 Are the physical, chemical, or biological measurements upon which this indicator is based widely accepted as scientifically and technically valid?

Yes. The data provide a variety of analyses relevant to determining status and trends in agricultural fertilizer use and agricultural acreage in the United States, and is based on estimates of on-farm fertilizer use which can be broken down by region or crop type. Fertilizer use is reported in either nutrient pounds or nutrient tons, as well as by the percentage of acreage to which fertilizer is applied for a specific crop. The National Agricultural Statistics Service (NASS) generates estimates, in million of acres, of the amount of estimated acreage of farmland in the United States. Data are collected from a list of farmers complied by NASS that produce or sell a certain amount of agricultural products annually.

T1Q2 Is the sampling design and/or monitoring plan used to collect the data over time and space based on sound scientific principles?

Yes. USDA conducts surveys in major-producing states for individual crops, most notably corn and soybeans. Collected via the Agricultural Resources Management Survey (ARMS), USDA estimates fertilizer use by state and crop based on a random sampling of farms, calculating the percentage of acreage treated with fertilizer, the average number of applications, the average amount per application, and the total amount of fertilizer applied. By calculating the total planted acreage in the ARMS program states versus the total national planted acreage, USDA calculates the percentage of total U.S. planted acreage program states account for, which can range between 65% and 97%, but is generally about 80%. From this, it can generalize national estimates, and compare them with the estimates based on fertilizer sales. For acreage reports, NASS conducts surveys for agricultural census data by mailing all members of the census mail list (CML) in Alaska and Rhode Island, and a sample of records in all other states. Records are selected based on several criteria, including size or volume of products sold, location in areas with fewer than 100 farms in 1997, or have other special characteristics that stand out. NASS has an extensive monitoring program that includes the use of scanned bar codes, computer assisted telephone interview software, and computer editing.
(http://www.ers.usda.gov/publications/arei/ah722/arei4_4/DBGen.htm.)

T1Q3 Is the conceptual model used to transform these measurements into an indicator widely accepted as a scientifically sound representation of the phenomenon it indicates?

Yes. Although issues on the ability to generalize the survey results to the national level might exist, the survey questions produce estimates that allow for analysis of trends in fertilizer use based on region and crop type.

T2Q1 To what extent is the indicator sampling design and monitoring plan appropriate for answering the relevant question in the ROE?

The question asks about trends and status in the use of chemicals on the land. Focusing on ARMS survey states, which are the major producing states for targeted crops such as corn, cotton, and soybeans, covers all types of farms and accounts for approximately 82% of all farmland in the U.S., with all farms on the list having an equal chance to be selected in any given year. Results are dependent on the number of surveys that are returned for each crop type in each state each year. For example, in 2003, 3,013 reports were collected for corn from 18 major producing states, which accounted for 92% of total U.S. planted corn acreage. For soybeans in 2002, 2,526 reports were collected in 20 major producing states, which accounted for 97% of total U.S. planted soybeans acreage. The datasets are typically published in May of the next calendar year. NASS conducts its acreage surveys the first two weeks in June. Surveys are based on a probability area frame survey with a certain number of segments or parcels of land and a certain number of farm operators. All farmers with operations within the sampled segments are contacted via telephone, mail, or personal interview.

T2Q2 To what extent does the sampling design represent sensitive populations or ecosystems?

Not applicable for either dataset.

T2Q3 Are there established reference points, thresholds or ranges of values for this indicator that unambiguously reflect the state of the environment?

USDA does not publish specific thresholds or reference points beyond which fertilizer use is thought to affect people or ecosystems.

T3Q1 What documentation clearly and completely describes the underlying sampling and analytical procedures used?

NASS produces an annual publication entitled Agricultural Chemical Usage, which includes targeted crops for that year as well as the sampling and analytical procedures. This encompasses the last 10-15 pages of each report, and also includes terms and definitions. Documentation for the 2003 survey can be found at http://usda.mannlib.cornell.edu/reports/nassr/other/pcu-bb/agcs0504.pdf, p. 148-149. The 2002 Census of Agriculture, which includes detailed information on the statistical methodology is available on the USDA web site at http://www.nass.usda.gov/census/census02/.

T3Q2 Is the complete data set accessible, including metadata, data-dictionaries and embedded definitions or are there confidentiality issues that may limit accessibility to the complete data set?

The complete dataset is not available to protect the interests of the farmers that participate in the surveys; the reports included summary data of the surveys broken down by crop and location. There is a description of methodology and reliability estimates.

T3Q3 Are the descriptions of the study or survey design clear, complete and sufficient to enable the study or survey to be reproduced?

The study requires knowledge of, and access to, data from several other USDA programs and reports. The study provides adequate definitions and descriptions of the relevant terms and methodology, as well as the survey instrument. Reproduction of the survey would be possible, assuming one had access to the farms included in the NASS sampling frame.

T3Q4 To what extent are the procedures for quality assurance and quality control of the data documented and accessible?

The estimation procedures and reliability are well documented in the annual reports, the link to which is located in T3Q1. Survey results are reviewed by USDA personnel, which also work with respondents that have questions. Ultimately, as the data are reported directly from farms, quality assurance and quality control is determined by the volume of responses.

T4Q1 Have appropriate statistical methods been used to generalize or portray data beyond the time or spatial locations where measurements were made (e.g., statistical survey inference, no generalization is possible)?

ARMS program states for targeted crops typically account for 80-99% of total U.S. planted acreage, especially for corn and soybeans, which are listed as examples in the indicator text. Because of this, generalization to the national level can be done with confidence. NASS conducted a Farm Identification Survey in 2002 to screen potential farms before placing them on the census mail list.

T4Q2 Are uncertainty measurements or estimates available for the indicator and/or the underlying data set?

Uncertainty measurements are available for acreage reports, but not for fertilizer applications.

T4Q3 Do the uncertainty and variability impact the conclusions that can be inferred from the data and the utility of the indicator?

The large screening sample frame from which the surveys were selected, coupled with the large number (> 1000) of reports and a sampling design which insured that all farms on the sampling frame had an equal chance to be selected, provides excellent data quality and improves the utility of the indicator.

T4Q4 Are there limitations, or gaps in the data that may mislead a user about fundamental trends in the indicator over space or time period for which data are available?

Figures on fertilizer use from the ARMS are generated from surveys of major producing (program) states for each crop, but the total U.S. planted acreage for which the program states account varies by year, depending on the number of reports and program states represented in a particular year for a particular targeted crop. As discussed in the indicator text, the fertilizer application rates and the percentage of total U.S. soybean acreage accounted for by ARMS states was rather consistent with the exception of 2001. In 2001, figures on the percentage of land treated with all three major types of fertilizer were much lower than in any other year between 1999 and 2002, and ARMS acreage accounted for only 71% of total U.S. planted acreage of soybeans, as compared to 92-97% in other years. This suggests that when fewer program states report their results (only 8 states reported in 2001, as opposed to 18-20 states in other years), the results can be affected. As fertilizer application rates can vary from state to state, omission of

program states can result in significant differences in results, and the inability to accurately and confidently generalize results to the national level.